

57. Sponges in Waterworks. By W. N. PARKER, Ph.D., F.Z.S., Professor of Zoology, University College, Cardiff.

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Some three or four years ago I received through my colleague, Dr. Schölberg, some specimens of a branched, yellowish-brown organism which had been found growing in some of the pipes at the Cardiff Waterworks, and which proved to be very fine examples of *Spongilla lacustris*. Subsequently I learnt that there had been an extensive growth of this sponge in the pipes leading to one of the series of filter-beds, which had caused much trouble and difficulty; and that, although the growth had apparently disappeared for a time after treatment with sulphate of copper, it, as I expected, soon appeared again, and became as flourishing as ever. In the summer of 1911 the growth was so extensive as to cause anxiety, not only as regards reducing the flow in the pipes, but also on account of the unpleasant odour which had been noticed in the water, due doubtless to the living sponge as well as to its decomposition. In December of the same year I was requested by the Waterworks Engineer, Mr. C. H. Priestley, to report on the matter to the Waterworks Committee; and now that the treatment I subsequently proposed has—at any rate for the present—been successful, I have the permission of the Committee to publish an account of our experiences. I should like to express my indebtedness to Mr. Priestley and his staff for their cooperation and for giving me every facility in prosecuting the enquiry; I have also to thank Dr. Kemna, of Antwerp, Dr. Harmer, Mr. Kirkpatrick, and Professor Minchin for valuable information given at the beginning of the investigation.

Although sponges of various species have been recorded at numerous other Waterworks*, they do not appear to have been the chief source of trouble, as at Cardiff.

The interesting subject of the fauna of Waterworks has quite recently been so fully dealt with by Dr. Harmer in these "Proceedings" (1913, p. 426), that it is unnecessary for me

* *E. g.* at Boston, Mass. (Bowerbank, Proc. Zool. Soc. 1863, & Potts, Acad. Nat. Sci. Philadelphia, 1881, 1882, and 1887); Hamburg (Kraepelin, Abh. Naturwiss. Ver. Hamburg, 1856); Torquay (Chapman, "Animal Growths in Water-pipes," Transactions of the Institute of Water Engineers, 1913, & Kirkpatrick—see Harmer, P. Z. S. 1913, p. 436); and Aberdeen (Kirkpatrick, *loc. cit.* p. 439).

to refer in detail to the history and literature of the subject. Dr. Harmer's account of the difficulties which have recently occurred in various English Waterworks owing to the presence of Polyzoa, shows the importance of biological investigation in dealing with such cases, as was pointed out in this country by Professor Hickson in his presidential address to Section D of the British Association at Southport in 1903.

The Cardiff district is supplied with excellent soft water from the Taff Fawr reservoirs in Brecknockshire, midway between Merthyr and Brecon. From these higher reservoirs the water is conducted by conduits into various other storage-reservoirs at a lower level, in the near neighbourhood of Cardiff, and from those into filter-beds: the latter, of course, prevent the access of organic particles and spicules into the service-pipes supplied from them. The sponge had hitherto only been found in the pipes leading to certain of the filters on the northern border of Cardiff known as the "Heath" filters, from which the greater part of the city is supplied. The water to these filters comes from two storage-reservoirs, at Llanishen and Lisvane, situated about a mile farther north. Careful examination has so far not revealed any trace of the sponge in other parts of the system, which therefore I need not describe further here*.

The water from Llanishen reservoir passes through metal screens with fine meshes, so as to strain off all but minute solid particles, into a valve-shaft from which it is conducted by underground pipes to a valve-chamber at the "Heath." It is then again screened before flowing into a 3-ft. pipe, with which lateral pipes are connected ending in bell-mouths, one to each of the six filter-beds.

The chief trouble occurred in this pipe, which was thickly lined with a luxurious growth of the sponge, consisting of dense incrustations giving off numerous finger-like processes which branched and branched again, and some of which reached a length of 8 inches or more, frequently showing concrecence †. Other growths were found in the valve-chamber and screen-chamber, in the corners and crevices of which it was not easy to get access to them.

On visiting the "Heath" on December 12th, 1911, the sponge, packed with gemmules, showed no signs of dying down for the winter, and it appeared to me that had it been desired to cultivate the organism, probably no better plan could have been devised than that furnished by the water-chambers and pipes

* For further details with regard to the Cardiff Waterworks, see a paper by C. H. Priestley, M.Inst.C.E., on the "Development of the Cardiff Water Supply," read at the Sessional meeting of the Royal Sanitary Institute at Cardiff on April 12th, 1912; also a description of the Waterworks by the same author issued from the Cardiff Waterworks Engineer's Office, 1908.

† Cf. figures by Bowerbank, "A Monograph of the British Spongiadae," Ray Society, 1864-1882; and Johnston, "A History of British Sponges and Lithophytes (Corallines)," London, Edinburgh, and Dublin, 1882.

(*cf.* Kraepelin, *loc. cit.*). It can grow as well in the dark, without zoochlorellæ, as in the light; and being effectively protected from frost and other adverse conditions, it seemed possible that it might continue alive during the whole winter. On the same day, we made a cursory examination at Llanishen and Lisvane, with no result; but on the following day, the reservoir-keeper, after emptying the valve-shaft at Llanishen, found a considerable growth at a depth of between 10 and 20 feet.

Since then, a careful look-out has been kept for the sponge throughout the entire system, but there has been no positive evidence of its occurrence in other parts, either in the open or in the underground pipes.

The two most important problems which presented themselves were—the destruction of the sponge in the infected area, and the prevention of re-infection throughout the whole system. As regards the latter, the only sound method would be the introduction of pre-filtration through sand, so as to starve the sponge by preventing the microscopic organisms (on which it and other “microphagous” organisms which might at any time appear depend for their nutriment) from passing into the pipes and reservoirs (*cf.* Kemna, quoted by Harmer on p. 432), as well as to keep out larvæ and gemmules. This method would take a long time to carry out and entail considerable expense; moreover, it would not be effective unless it could be adopted at the lower reservoirs (where there are difficulties as regards level) as well as the higher ones, as there would be a reappearance of organisms in them. As the matter was urgent, I therefore felt it would be better to confine attention at first to the destruction of the organism in the infected area and the prevention of its regeneration and of reinfection by the gemmules.

Treatment with any destroying agent except such as would be dangerous to human life would be ineffective if applied to the adult sponge, as it would not destroy the myriads of gemmules protected by their resistant coats. It was therefore necessary in the first instance to make a periodical examination of the sponge for a year or more, so as to ascertain (1) whether sexual reproduction occurred, (2) when the gemmules germinated, and (3) whether the adult growth perished partially or entirely during the course of the winter*.

An examination of specimens at various times of the year has so far revealed no larvæ or any signs of sexual reproduction; but the enormous production of gemmules throughout the crusts and branches is quite sufficient to start new growths in any part to which the gemmules could gain access. There can be no doubt that a sexual stage is unnecessary for the reproduction of the sponge from year to year.

* *Cf.* Marshall (SB. Naturf. Gesellsch., Leipzig, 1884, & Journ. Roy. Micros. Soc. v. 1885); Weltner (Archiv f. Entwicklungsmechanik, Bd. xxxiii. Heft 3 u. 4).

On visiting the "Heath" and Llanishen on February 3rd, 1912, when the filter-beds were covered with ice $1\frac{1}{2}$ ins. thick, we found that the adult growth was dying down, but that it was still closely packed with gemmules, some of which had begun to germinate and start new growths among the old. On March 23rd gemmation had proceeded further, new growths being abundant, and I suggested that in the course of the spring the pipes and chambers should be scraped and treated with strong brine, so applied as to reach any small spaces and crevices in which gemmules could lodge, and thus to attack the sponge when it was least capable of resistance. This was done on May 2nd, and with the sponge were removed a large quantity of iron corrosive nodules—another trial to the Water Engineer, referred to by Harmer on pp. 430, 437, & 438 of his paper; the brine was then washed out through a bye-pass. The result was apparently satisfactory, but in the course of the summer a few small new growths were observed by the Foreman: they were very much less abundant than in the previous summer, and no smell had been noticed since the treatment. An examination on September 24th showed that these comparatively few young incrusting sponges had not yet given rise to any outgrowths, and that they contained no gemmules: they were in all probability due to a few gemmules which had not germinated when the treatment was carried out. I therefore suggested a second application of brine. By November 14th, when this was done, the growths had increased in size considerably, but apparently no gemmules had been formed. Instead of leaving the pipes empty for only a few hours, as on the previous occasion, it was possible this time to give them three days before being again used, and since then no trace of the sponge has been seen.

It is interesting to note that no Polyzoa were found, but that a number of colourless Hydræ like those described by Kraepelin at Hamburg were obtained by the reservoir-keeper from the bottom of the valve-shaft at Llanishen on May 25th; unfortunately these were all dead by the time they reached me*.

* Since the above was written, a few young sponge-growths were again observed and at once destroyed. Colonies of *Cristatella*, with numerous statoblasts, had also appeared: fortunately this is not one of the "moss"-forming Polyzoa. (Oct. 25th, 1913.)